Silver Diamine Fluoride and Urgent-Care While Awaiting General Anesthesia

By
BRIANA MOODY
B.A, Saint Louis University 2015
D.D.S, Marquette University School of Dentistry 2019

THESIS
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Thesis Committee:
Sahar Alrayyes, Chair and Advisor, Pediatric Dentistry
Helen Lee, Anesthesiology
Marcio da Fonseca, Pediatric Dentistry
Nadia Kawar, Periodontics
Charles LeHew, Pediatric Dentistry

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LIST OF ABBREVIATIONS

AAPD	American Academy of Pediatric Dentistry
ADA	American Dental Association
CI	Confidence Interval
COD	College of Dentistry
ECC	Early Childhood Caries
ED	Emergency Department
EHR	Electronic Health Record
EPA	Environmental Protection Program
FDA	Food and Drug Administration
GA	General Anesthesia
IRB	Institutional Review Board
NOAEL	No Observable Adverse Effect Level
RfD	Reference Dose
ROS	Reactive Oxygen Species
SDF	Silver Diamine Fluoride
S-ECC	Severe Early Childhood Caries
SES	Socioeconomic Status
UC	Urgent Care
UIC	University of Illinois Chicago

SUMMARY

At the University of Illinois at Chicago (UIC), College of Dentistry (COD), complete oral rehabilitation under general anesthesia (GA) is offered to children who have extensive oral healthcare needs and the inability to cooperate due to young age, special health care needs (SHCN), severe anxiety, limited maturity, or excessive dental needs. While complete oral rehabilitation under GA is often the best way to deliver dental treatment safely and successfully for those indicated above, it may not be provided in a timely manner due to limited provider availability, hospital or surgical center availability, or financial limitations for the family. While awaiting the completion of oral rehabilitation under GA, patients may experience pain related to dental caries and infection/dental abscess as a result of caries progression, then they may present to the urgent care (UC) clinic prior to the scheduled GA surgery date.

Since its introduction at UIC COD, silver diamine fluoride (SDF) has been commonly used as an interim treatment solution for patients who cannot tolerate more advanced and definitive treatment options. SDF has been found to be safe and effective in arresting caries. For patients awaiting complete oral rehabilitation under GA, SDF application offers the possibility of arresting caries, reducing sensitivity, and reducing the negative impacts of caries progression, thus reducing utilization of UC prior to GA.

This study is a retrospective chart audit of patients who were both placed on UIC COD's GA waitlist and received GA between January 1, 2017- April 1, 2020. The aim of this study was to determine whether SDF application was associated with patients presenting for UC visits while awaiting definitive treatment under GA. The main variables of interest included GA wait time, UC history, and SDF history. Of 1300 charts reviewed, 628 were selected for the study. Of the total study population, 37% received SDF, 21% had at least one UC visit, and 54% were considered to have SHCN. The total average wait time for GA was found to be approximately 349 days.

We found that longer wait times for GA increased the risk of presenting to UC prior to GA date. SDF application delayed UC presentation; however, it had a positive relationship with UC presentation. On average, UC presentation occurred around 6 months after GA waitlist placement. To reduce risk of an adverse event in patients waiting for GA, wait time should not exceed 6 months.

1. INTRODUCTION

1.1 Background

Dental caries is the most common chronic disease in children. If left untreated, it will lead to systemic health consequences and result in pain, dental abscess formation, destruction of bone, development of dentofacial anomalies and even septicemia (1). Some children with extensive oral health care needs, acute situational anxiety, uncooperative age-appropriate behavior, or with SHCN need general anesthesia in order to receive their dental care in a safe and less traumatic environment (2). Access to general anesthesia services in a hospital-based setting may be restricted due to limited insurance coverage, increasing waiting time.

In 2014, the Food and Drug Administration (FDA) approved SDF as a desensitizing agent, and has since been adopted in dentistry for its off-label use as an arresting and preventative dental caries agent (3). Due to the prolonged wait time of pediatric patients at the University of Illinois at Chicago to receive complete oral rehabilitation under general anesthesia, SDF application is recommended to help arrest carious lesions, prevent the progress of these carious lesions and limit adverse events.

1.2 Purpose

The primary purpose of this study was to determine whether the application of SDF reduces the number of patients presenting for UC visits while awaiting definitive treatment under GA.

Secondly, this study analyzes trends and impacts associated with prolonged wait time for definitive treatment under GA using descriptive data from the UCvisits.

1.3 Null Hypotheses

Our null hypotheses include:

$H_1 0$: The application of SDF does not impact the probability of presenting to UC while on the GA waitlist.

$H_2 0$: There is no association between presentation to UC and GA wait time.

2. LITERATURE REVIEW

2.1 Early Childhood Caries (ECC)

In the US, dental caries is one of the most common diseases faced by children aged 6 to 11 and adolescents aged 12 to 19 years of age (4). ECC is defined by the American Academy of Pediatric Dentistry (AAPD) as “the presence of one or more decayed (non-cavitated or cavitated lesions), missing (due to caries) or filled tooth surfaces in any primary tooth in a preschool-age child between birth and 71 months of age. In children younger than 3 years of age, any sign of smooth-surface caries is indicative of severe early childhood caries (S-ECC). From ages 3 through 5, 1 or more cavitated, missing (due to caries), or filled smooth surfaces in primary maxillary anterior teeth or a decayed, missing, or filled score of ≥4 (age 3), ≥5 (age 4), or ≥6 (age 5) surfaces constitutes S-ECC.” (5). Dental caries occur when bacteria in the mouth metabolize fermentable sugars and produce acid on the tooth surface. The acid produced leads to demineralization of tooth structure (enamel and dentin). When the balance of remineralization and demineralization is disturbed, tooth surface breakdown occurs (6). The key factors in the establishment and progression of dental caries include the microbiological environment, feeding practices, and sugar intake (7). There are many species of bacteria within the oral microbiome however the bacteria most commonly associated with dental caries include S. mutans and (to a lesser extent) lactobacillus (7,8). Inappropriate feeding practices like bedtime use of bottles with milk or sweetened beverages, on-demand breastfeeding, and nighttime breastfeeding, increase the amount of time enamel is exposed to fermentable sugars and acidogenic conditions, playing a major role in ECC (9,10). Increased frequency of sugar intake and retention of these sugars in the mouth due to absence of adequate oral hygiene practice increases the risk for caries development and progression (8). Although dental caries is one of the most common diseases faced by children in the US, it is largely preventable (4). Aside from good oral hygiene, appropriate dietary habits, limited intake of sugar, the presence of fluoride (in the saliva, drinking water, toothpaste, and other supplements) contributes significantly to prevention of dental caries (4,8).

While the etiology of caries is a rather simple one compounding risk factors, including socioeconomic status (SES) and SHCN can make ECC more complex. There is an inverse relationship between income, the presence of a SHCN, and ECC; where children from lower income families and/or children with SHCN are at an increased risk for experiencing early childhood caries (11,12). Dental caries disproportionately affects children who are disadvantaged economically, educationally, and socially (13). Poor maternal oral health and lower education status are associated with lower SES, and socioeconomic disadvantage increases the risk of ECC amongst their children (14).

Children living with ECC face several consequences including an increased risk of new carious lesions in both primary and permanent dentitions, higher treatment cost, hospitalizations and emergency room visits, and reduced oral health-related quality of life (15). Untreated caries can lead to caries progression, pain and infection, more difficult procedures, and more costly treatment options (16). In a study comparing the height, weight, and head circumference of children aged 3 to 5 years with ECC to children without, the children with ECC more frequently measured less than ideal height and weight as compared to their caries free counterparts (17). Not only does ECC affect overall health and growth, it has been found that poorer oral health correlates with increased loss of school days, decreased ability to learn, and negatively impacts academic performance (18,19). Overall, children living with ECC experience negative effects on their quality of life, including negative impacts on eating, sleeping, behavior, productivity, confidence, ability to learn, and overall health. (21-23). Following dental treatment, including complete rehabilitation under general anesthesia (GA), patient’s oral health related quality of life improves (23,24)

2.2 General Anesthesia as a Treatment Approach for ECC

When anxiety, age/maturity, behavior, or medical status prevents routine treatment from occurring in the dental office, GA is an effective advance behavior guidance treatment modality. General anesthesia is indicated for children who have extensive oral healthcare needs, acute situational anxiety, and the inability to cooperate. This is applicable for very young uncooperative children and children with special health care needs who have immature cognitive functioning, disabilities, medical conditions, or other special health care needs that require general anesthesia to receive dental treatment safely (2, 25). The use of GA minimizes the number of visits for the anxious patients, however, immediate access to GA remains limited.

Long GA wait times are not uncommon throughout the US and can be attributed to several different factors (26). Firstly, GA is a costly treatment method that is often poorly reimbursed. Many children with ECC come from families of lower socioeconomic status and/or have a SHCN, and Medicaid is often responsible for these treatment costs in the US. Burgette and Quinonez reported that the direct cost to Medicaid for a GA visit at a university-based hospital in 2015 ranged from $11,731 and $13,331 (27). This range includes the reimbursement to the hospital, the cost of dental procedures, and the reimbursement to the anesthesiologist. Bruen et.al reported that across 6 states, children who underwent GA in 2011 either in a hospital operating room or ambulatory surgery center made up approximately 0.5% of all children enrolled in Medicaid. The total dental expenditure totaled approximately 68 million dollars, with each case averaging $2,581. Majority of care provided was related to dental caries to children between 1 to 5 years of age (28). A separate study by Kanellis, et al, found that less than 2% of children under 6 years of age who are enrolled in the Iowa Medicaid system accounted for 25% of the total expenditure on dental services. This suggests that prevention, early diagnosis, and intervention, for high-risk populations should be employed at an early age in an effort to reduce the need and expenditure of dental services under GA (29).

Secondly, in areas where dental treatment under GA is in high demand, limited trained professionals who deliver treatment via GA as well as participate in Medicaid also leads to longer wait times for treatment (30). Average waiting times for children awaiting GA in the United States have been found to be 6-7 months (31), 7-8 months (32), and 1-2 years (30).

2.3 Effects of Delayed Treatment and Pediatric Dental Emergencies

During these wait times, many children present to dental offices, dental clinics, and/or hospitals seeking emergency dental treatment prior to their GA appointment date. Longer wait times create negative impacts on the quality of life for these children. These impacts include need for analgesics and antibiotics because of pain and infection prior to GA date, sleep disturbances, missed school days, and problems with eating (32). In a study by North et. al, 53% of the children who waited six months for treatment under GA sought dental advice during their wait. Of that cohort, 41% required analgesics during their wait, 49.4% were prescribed antibiotics on at least one occasion, 28.5% reported problems sleeping, 32.9% reported problems eating, and 9.2% reported missed school time (33). In a similar study by Chung et. al, found that long wait times for treatment under general anesthesia resulted in emergency visits in which dental pain was the most common chief complaint (3)

Oftentimes when patients lack dental insurance coverage or are enrolled in Medicaid, do not have a dental home, or lack access to dental treatment in a dental facility, the emergency department (ED) is the place they present for dental emergencies (34). Common dental emergencies for which children present to the ED include dental trauma, dental pain and/or infection related to caries, and other emergencies which can include orthodontic emergencies or exfoliating teeth (3,35-36). A study within a university based emergency setting reported that 82% of patients reported pain was the reason for the ED visit (36). Seventy nine percent of the ED visits were due to consequences of caries progression. Of the patients within the North et al. cohort, 65% of parents reported the duration of the complaint had lasted 30 days or more (33).

2.4 Silver Diamine Fluoride (SDF)

Definitive treatment like restorations and extractions cannot be completed for some children on the GA waitlist; accordingly, the application of SDF offers a new treatment approach aimed at arresting caries and delaying traditional surgical removal of caries in patients who are unable to tolerate conventional dental care (37,38). Silver diamine fluoride is a desensitizing agent approved by the Food and Drug Administration (FDA) in 2014 that has been adopted in dentistry for its off-label use, arresting and preventing dental caries. Since its adoption in dentistry and production in the US, SDF has become a viable and popular treatment option given its efficacy and efficiency, safety, and affordability (39). Our current understanding is that SDF is a bi-functional agent, it arrests dental caries by combining the antibacterial effect of silver nitrate and the capacity of fluoride to remineralize enamel and dentin by replacing the OH ions with F ions in hydroxyapatite, creating fluorohydroxyapatite a compound that is less soluble than hydroxyapatite (39). While SDF is a bi-functional agent, there are 3 mechanisms of action of SDF that may explain its success.

The first mechanism is the obturation of dentinal tubules. When carious lesions are treated with SDF, a layer is formed over the dentinal tubules, partially plugging them. It has also been shown that aqueous silver forms a protective layer over the dentinal tubules. This physical barrier prevents acidogenic and cariogenic bacteria from invading the dentinal tubules, thus arresting caries. Obturation or occlusion of the dentinal tubules helps decrease sensitivity of teeth (40,41).

The second mechanism of action is SDF's ability to inhibit bacterial colonization and induce bacterial cell death. SDF contains silver nitrate, which has been shown to reduce the growth of cariogenic bacteria like S. mutans and L. acidophilus (42). The mechanism of action of silver nitrate on cariogenic bacteria is not fully understood; however there are several studies whose findings suggest that silver nitrate is antibacterial. Pandian et. al found that silver nitrate at higher concentrations inhibit thiol group-containing enzymes. This in turn, results in an increase in reactive oxygen species (ROS). Ultimately, the increase of ROS within the cell induces apoptosis, or cell death (43). In another study, it is concluded that "silver ions interact with sulfhydryl groups of proteins and DNA altering hydrogen bonding, thus inhibiting respiratory processes, cell wall synthesis, and cell division. At the macro level, these interactions affect bacterial killing and inhibit biofilm formation" (44). Although the mechanism of action of silver nitrate on bacteria has been highly debated, there is no debate that silver ions are responsible for the bactericidal effects exhibited in SDF (45).

The third mechanism of action is the remineralization of dentin and enamel. Caries lesions treated with SDF show reduction in demineralization of dentin and increased remineralization of dentin and enamel. This is largely due to the second main component of SDF, sodium fluoride. Fluoride promotes the remineralisation of hydroxyapatite in enamel and dentine (40). After the application of SDF to a decayed surface, Horst et al explains that resistance to acid dissolution and enzymatic digestion increases. “Hydroxyapatite and fluorapatite form on the exposed organic matrix, along with the presence of silver chloride and metallic silver. The treated lesion increases in mineral density and hardness while the lesion depth decreases. Meanwhile, SDF specifically inhibits the proteins that break down the exposed dentin organic matrix: matrix metalloproteinases; cathepsins; and bacterial collagenases” (41).

Silver diamine fluoride has proven to be an effective medicament and treatment modality for arresting dental caries in primary and permanent dentitions. In the systematic review and meta analysis by Chibinski, et al, SDF was shown to be 89% more effective in arresting and controlling caries than other treatments or no treatment (46). In a 36-month clinical trial, 38% SDF was shown to be effective in arresting caries in the primary dentition of 6 year old children and in prevention of caries in the first permanent molars. This study found that 77% of treated caries became inactive during the 36 month study (47). Efficacy of SDF has also been studied in relation to frequency of application as well. In a clinical study, SDF was shown to be effective in arresting caries in primary teeth of 2-3 year olds after a single application however effectiveness was shown to decrease over time. This study suggests increased frequency of application to 6 month intervals can increase caries arrest rates over time (48). Other clinical trials on the efficacy of SDF in arresting caries in primary teeth found that increased application intervals, more than once a year, increased the rate of arrested caries in the primary dentition (49-51).

When SDF is used appropriately it is safe and has limited adverse reactions. SDF contains approximately 24-28% (weight by volume) silver and 5-6% (weight by volume) fluoride . One drop of SDF, on average, weighed approximately 25 μL (52) . Exposure to one drop of SDF orally would result in less fluoride ion content than is present in a 0.25 mL topical treatment of fluoride varnish, per the AAPD (53). A study that measured fluoride and silver serum levels following application of SDF, found that the fluoride exposure was below the reference dose (RfD) outlined by the Environmental Protection Agency (EPA) and the amount of silver used in the application was 75 times less than that of the no observable adverse effect level (NOAEL) for acute exposure of 14 continuous days. Argryia, a rare skin condition that occurs when silver builds up in the body over a long period of time, has been proposed to be an adverse effect of SDF. However, this study concluded that the amount of silver exposure during application of SDF was well below the level of toxicity, serum levels recorded in the study were well below serum levels associated with argyria. Thus, suggesting that a single SDF treatment, when used appropriately, poses no toxic risk (53). More commonly reported adverse events include the characteristic black staining on the carious lesions, mucosal staining, and surface staining (counters, clothing, etc.). The black staining of the enamel and dentin lesions is associated with caries arrest and is permanent. Staining can only be removed during definitive treatment. Unfortunately, although SDF has been proven effective in arresting caries, the black staining and dental appearance is often a source of parental dissatisfaction (51). Mucosal staining of the gingiva and other soft tissues of the oral cavity and perioral region was found to be a common adverse event that was resolved in 2 days (on average) without intervention or further treatment (51). SDF is inexpensive, requires limited supplies, and minimal chair time for application. It has been found to be effective in arresting caries and its application is simple and non-invasive. There have been no reports of systemic fluoride or silver toxicity when used appropriately. SDF is a non-invasive, effective, safe, and affordable treatment option that can be used to arrest active decay of children awaiting general anesthesia for complete oral rehabilitation.

3. MATERIALS AND METHODS

3.1 Subjects

This study was a retrospective chart audit of a sample of patients on the University of Illinois at Chicago College of Dentistry (UIC COD) GA waitlist from January 1, 2017 to April 1, 2020. Charts were accessed through the UIC COD electronic health record (EHR) system. Protocol #2020-0705 was approved as exempt status by the UIC Institutional Review Board (IRB).

Each chart was assessed individually to determine if inclusion or exclusion criteria were met. Patient information was de-identified and all data points were collected on an Excel sheet (Microsoft; Santa Rosa, CA), as displayed in Appendix A.

3.1.1 Inclusion Criteria

- Pediatric patients (up to age 17) who were both placed on the GA waitlist and underwent complete oral rehabilitation under GA between January 1, 2017 and April 1, 2020.
- Completion of GA billing code D9219 (General Anesthesia- Peds Record) along with the associated date of surgery in Axium.
- Patients with a dmft/DMFT score of ≥ 1 (i.e., at least one decayed, missing, filled, or treated tooth due to caries)

3.1.2 Exclusion Criteria

- Patients who did not undergo complete oral rehabilitation under GA
- Patients who underwent treatment elsewhere
- Patients who scheduled and received restorative care in the clinic
- Locked out charts due to due to financial or administrative disputes

3.2 Independent Variables

Patients' demographics were extracted from their UIC COD electronic health records including the patient' age (defined as approximate age in years at the date of GA waitlist placement), sex (male or female), race (African American, Alaskan Native, American Indian, Asian, Caucasian, or "Not Reported"), and ethnicity (Hispanic or Non-Hispanic) as reported by the parent or legal guardian and recorded at the time of patient registration.

Every patient's medical history was reviewed to determine whether the patient was medically healthy or had special health care needs. For the purpose of this study, any patient with identified medical, developmental, psychiatric, or physical disabilities (as indicated in the "Pediatric Form", "Medical History" tab, and/or verified note entry) was considered a patient with special health care needs. Patients with existing medical conditions who are classified by the American Society of Anesthesiologists (ASA) as classification of ≥ II were considered special needs. Patients who are with no contributory medical, developmental, psychiatric, or physical disabilities were identified as healthy patients. In addition, any patient with a history of mild resolved condition (including prematurity at birth without complications, mild anemia, or past minor surgical history without complications) was considered healthy.

The total time a patient waited for GA in days was recorded. This time was defined as the number of days between GA waitlist placement (Day 0) and GA completion (Day X), reflecting the total time a patient waited to receive complete oral rehabilitation under general anesthesia. The GA waitlist placement date, (Day 0), was preliminarily recorded on the COD's electronic GA waitlist. Protocol for official placement on the waitlist included review of patient information and official placement on the waitlist by GA coordinator, following submission of

GA waitlist form by the resident. The GA waitlist date was collected from COD's electronic GA waitlist, and verified by reviewing note entry at appointment during which it was stated they were placed on the GA waitlist. Day X, GA completion date, was identified by the completed code D9219 ("General Anesthesia- Peds Record") in Axium. GA waitlist time was calculated in days (Day X-Day 0), using SPSS data analysis software (version 25, IBM Corporation, Armonk, NY). The type of visit in which a patient was recommended for treatment under GA and placed on the waitlist was also recorded (initial exam, recall exam, unsuccessful or failed restorative procedures, or UC visit).

The decayed, filled and missing primary and permanent teeth due to caries (dmft/DMFT) score was tabulated by reviewing the patients' odontogram recorded on the date of waitlist placement. A tooth is marked absent or missing from the odontogram when a tooth is not present clinically due congenital absence or due to extraction because of caries (with or without prior restorative history). The dmft scores were collected and categorized into several groups, including dmft scores between 0-7, 8-10, 10-13, 14+ as these categories were representative of the sample. Many of these patients were pre-cooperative or unable to tolerate treatment chairside where radiographic assessment was not used to identify caries or dmft/DMFT score.

SDF application is a beneficial caries management therapy for children awaiting treatment under general anesthesia. Several applications may be needed to sustain the caries arrest. Many parents/legal guardians consented to their children receiving SDF application while awaiting treatment under GA. Completed EHR codes D1354 ("Interim caries arresting medicament- SDF") or D1354NC ("Interim caries arresting medicament-SDF NC") were used to record SDF history. Because documentation of SDF application has changed since its first introduction at UIC COD, note entry within the EHR was used to collect and record information about SDF history as well. Other information recorded regarding SDF history included the application of SDF recorded as “Yes” or “No”, the number of applications during the wait period, and visit type at first time application (i.e. initial exam, recall exam, unsuccessful or failed restorative procedures, or UC visit).

3.3 Dependent Variables

The outcome variable of interest was presentation to UC defined as, for the purpose of this study, an adverse event occurring during the wait period for definitive treatment under GA. Information regarding UC visits was collected quantitatively and descriptively. History of UC visits was identified by completion of code D0140 “Limited Exam” (routinely used at UIC COD for problem focused exams in urgent care clinic). Quantitative information collected regarding UC visit(s) during the wait period includes history of UC visit (“Yes” or “No”), number of UC visits, and date of UC visits. Time between GA waitlist placement (Day 0) and first presentation to UC was calculated and recorded in days. Descriptive data collected about UC visits include chief complaint at time of visit (i.e., pain, infection/abscess, caries burden increasing, sensitivity, and temporization needs), type of treatment provided at UC visit identified by the corresponding codes (extraction, sedative filling, pulp therapy, antibiotic prescription, monitor until GA, and SDF application), and the use of protective stabilization (recorded as “Yes” or “No”). Use of protective stabilization (PS) was identified via EHR note entry on the date of UC visit, obtained parental signed consent forms, and/or completed code D9925 – “Behavior management – papoose use N/C”.

3.4 Statistical Analysis

Data analysis was completed using both descriptive and inferential statistics. Frequency distributions were examined for all demographic variables. Differences in UC outcomes between SDF vs non-SDF, special needs vs healthy, age categories, and dmft/DMFT categories were analyzed using Chi-square. UC trends for SDF group and non-SDF group, as well as average period of time between GA waitlist placement were also analyzed using Spearman's correlation. The correlation between SDF application and dmft/DMFT score categories was also investigated using Spearman's rho. Logistical regression analysis was done to determine the biggest predictor of UC visit, including SDF history, age, dmft, ethnicity, or wait time. For patients receiving SDF, independent samples t-tests were run to analyze if application would delay UC visits for patients, in total and categorically. Significance level of $p < 0.05$, and a confidence interval (CI) of 95% were applied.

4. RESULTS

4.1 Descriptive Statistics of Sample

Out of 1,300 patients on UIC COD's GA waitlist, 628 met the inclusion criteria for the study. The average age of the studied sample was 4.9 years (SD +/- 3 years) (Table I). More males than females were included in the study (Figure 1). The majority of our sample identified themselves as White and/or reported their ethnicity as Hispanic (Figures 2 and 3). Over half of the sample (53.7%) were identified as patients with SHCN. Two hundred thirty-five (37.4%) received SDF at least once and 134 (21%) had an UC visit. Patients were most frequently placed on the GA waitlist at the initial exam. The average wait time for GA was 349 days (SD+/- 160 days), range: 18 to 970 days. Almost 60% of the patients had to wait over one year for GA, and 12 children had to wait over two years prior to receiving treatment.

Table I

DEMOGRAPHIC INFORMATION OF TOTAL STUDY SAMPLE

Characteristic	N=628 (100%)
Sex	
Male	366 (58.3%)
Female	262 (41.7%)
Age [a]	
0-2 years	173 (27.5%)
3-5 years	297 (47.3%)
6-11 years	131 (20.9%)
≥ 12 years	27 (4.3%)
Race	
African American	60 (9.6%)
American Indian/Alaskan Native	9 (1.4%)
Asian	30 (4.8%)
Native Hawaiian/Pacific Island	1 (.2%)
White	399 (63.5%)
Not Reported	129 (20.5%)
Ethnicity	
Not Reported	129 (20.5%)
Hispanic	302 (48.1%)
Non-Hispanic	197 (31.4%)
Medical Status	
Healthy	291 (46.3%)
Special Needs	337 (53.7%)
DMFT/dmft[b]	
0-7	135 (21.5%)
8-10	167 (26.6%)
11-13	163 (26%)
≥14	163 (26%)
Urgent Care History	
Yes	134 (21.3%)
Total Wait Time until GA (mean)[c]	
Days	349 (SD ±160)
Days Until Urgent Care[d]	
	189 (SD±158)

[a] Mean Age; [Total Sample: 4.9 years, SD 3.0]
[b] Average DMFT; [Total Sample: 2.56, (11-13 dmft score)
[c] Mean GA Wait Time; [Total: 349 days, SD 160]
[d] Days to UC: [Total: 189 days, SD 158]

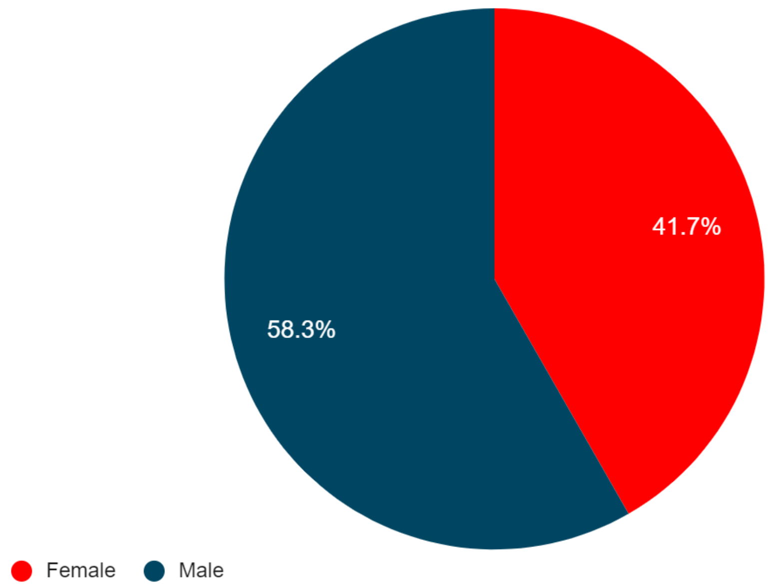

Figure 1. Sex distribution of the total sample

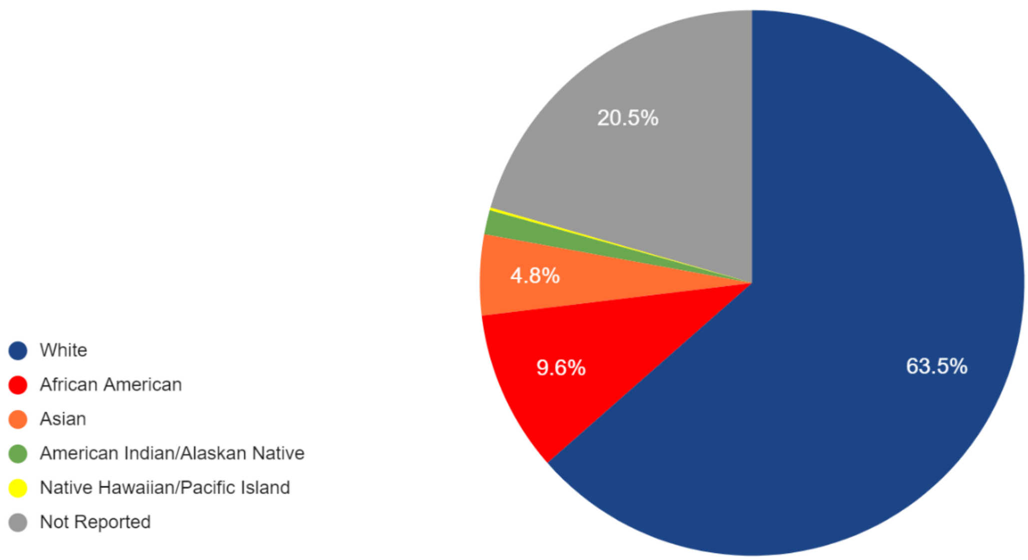

Figure 2. Race distribution of the total sample

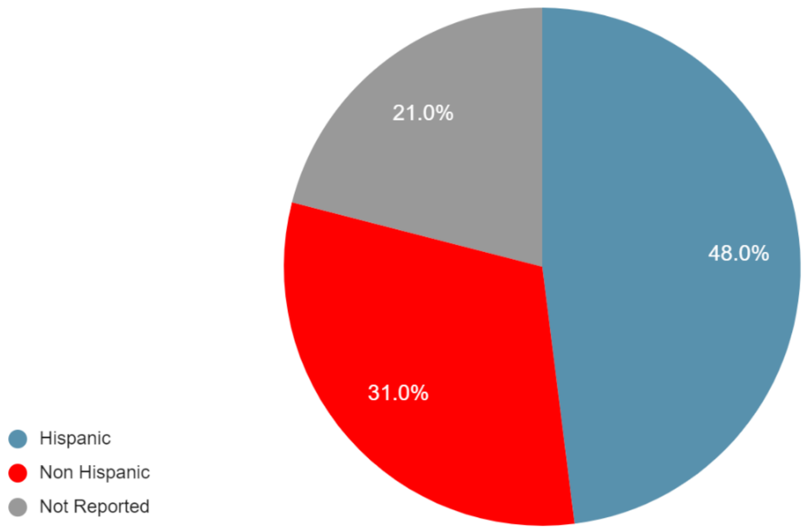

Figure 3. Ethnicity distribution of the total sample

4.1.1 Urgent Care

Twenty-one percent of the total presented for UC at least once during the GA waiting period (Table II). The mean age of patients presenting to UC was 4.1 years for the healthy patient and 5.1 years for patients with SHCN. More males presented to UC. More UC patients identified their race as white and their ethnicity as Hispanic. The average time between placement on the waitlist and UC encounter was 189 days (SD+/-158 days). Most patients who presented for UC during their wait period for GA only presented once. Approximately 4% (26 patients) presented to UC twice and 2% (8 patients) presented to UC three times during their wait for GA.

Table II
DEMOGRAPHIC INFORMATION OF TOTAL UC SAMPLE

Characteristic	UC N=134 (21%)
Sex	
Male	79 (59.0%)
Female	55 (41.0%)
Age [a]	
0-2 years	49 (36.6%)
3-5 years	66 (49.3%)
6-11 years	14 (10.4%)
≥ 12 years	5 (3.7%)
Race	
African American	11 (8.2%)
American Indian/Alaskan Native	3(2.2%)
Asian	8 (6.0%)
Native Hawaiian/Pacific Island	0 (0%)
White	84 (62.7%)
Not Reported	28 (20.9%)
Ethnicity	
Not Reported	28 (20.9%)
Hispanic	64 (47.8%)
Non-Hispanic	42 (31.3%)
Medical Status	
Healthy	67 (50%)
Special Needs	67 (50%)
DMFT/dmft[b]	
0-7	22 (16.4%)
8-10	34 (25.4%)
11-13	42 (31.3%)
≥14	36 (26.9%)
Total Wait Time until GA (mean)[c]	
Days	404 (SD ±154)
Days to Urgent Care[d]	
Days	189 (SD ± 158)

[a] Mean Age; [UC 4.08, SD 2.7 years]
[b] Average DMFT; [UC: 2.69 (11-13 dmft score, SD 1.0]
[c] Mean GA Wait Time;[UC: 404 days, SD ± 154]
[d] Days to UC: [Total: 189 days, SD ± 158]

The most common chief complaint at the UC visit was pain, followed by infection/abscess, caries getting larger, and sensitivity (Figure 4). The most common procedure performed at UC was extraction (Figure 5). To complete treatment in UC, PS was needed for 68.7% of the UC patients. DMFT/dmft score, and patient's health were not associated with UC encounter ((X^2 (4, N = 628) =4.6 , p = 0.33) and ((X^2 (1, N = 628) =0.919 , p = 0.33) respectively. However, young age and SDF application were associated with UC encounter ((X^2 (3, N = 628) =14.1, p = 0.003) and ((X^2 (1, N = 628) =11.5, p = 0.001) respectively.

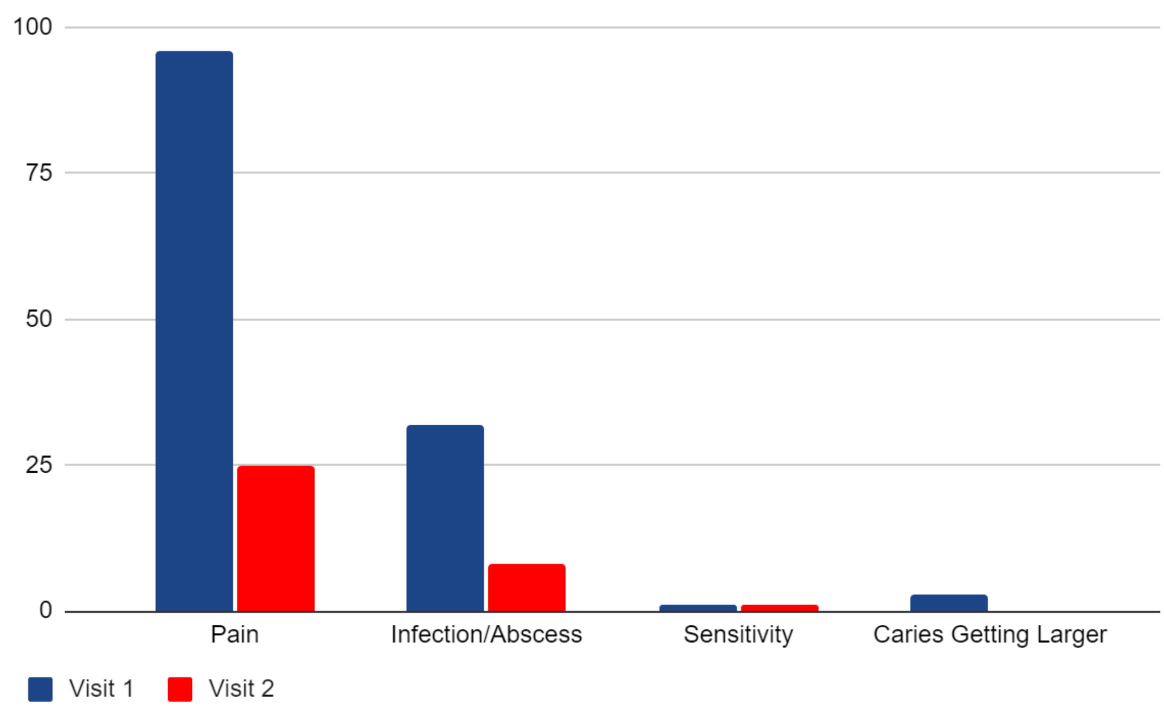

Figure 4. Chief Complaint at UC Visit 1 and 2

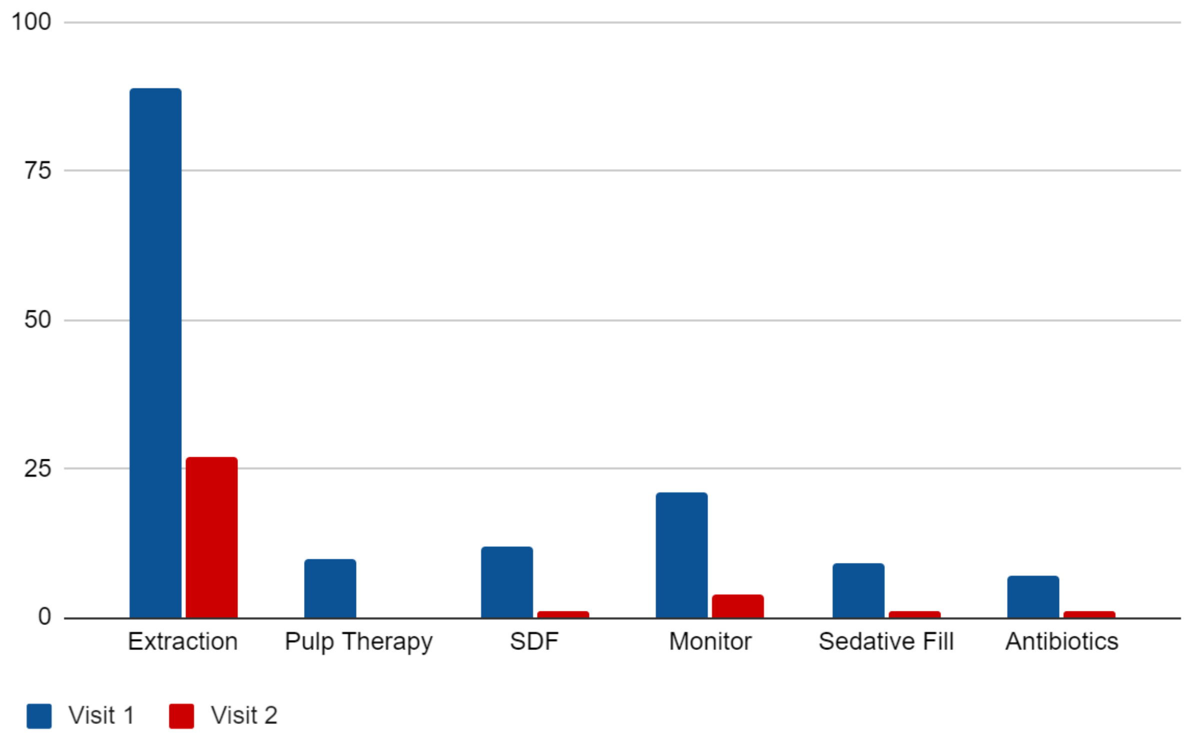

Figure 5. Procedure completed at UC visit 1 and 2

4.1.2 SDF vs. Non-SDF Patients

The characteristics of those who received SDF and did not receive SDF are demonstrated in Table 3. The most frequent appointment type in which SDF was placed was at the initial exam. Patients who received SDF had an average GA wait time of 358 days (SD +/- 149 days) whereas, patients who did not receive SDF had an average wait time of 344 days (SD +/- 166 days). There was a positive correlation between the waiting time for GA and UC encounters (r= .172, P = .000). Patients who received SDF tended to be younger (mean age =3.6 years), while those who did not receive SDF were older (mean age=5.8 years). More males and Hispanics received SDF than females. More of the healthy population received SDF (44.5%) than the special needs patients (31.2%). In addition to that, more healthy children who received SDF presented to UC than did patients with a SHCN who received SDF. However, this finding was not significant (p=.758).

Table III

SDF GROUP VS NON-SDF GROUP DEMOGRAPHICS

Characteristic	SDF N= 235 (37%)	Non-SDF N= 393 (63%)
Sex		
Male	136 (57.9%)	230 (58.5%)
Female	99 (42.1%)	163 (41.5%)
Age [a]		
0-2 years	102 (43.4%)	71 (18.1%)
3-5 years	114 (48.5%)	183 (46.6%)
6-11 years	16 (6.8%)	115 (29.3%)
≥ 12 years	3 (1.3%)	24 (6.1)
Race		
African American	13 (5.5%)	47 (12%)
American Indian/Alaskan Native	2 (.9%)	7 (1.8%)
Asian	15 (6.4%)	15 (3.8%)
Native Hawaiian/Pacific Island	0 (0%)	1 (.3%)
White	154 (65.5%)	245 (62.3%)
Not Reported	51 (21.7%)	78 (19.8%)
Ethnicity		
Not Reported	51 (21.7%)	78 (19.8%)
Hispanic	120 (51.1%)	182 (46.3%)
Non-Hispanic	64 (27.2%)	133 (33.8%)
Medical Status		
Healthy	130 (55.3%)	161 (41%)
Special Needs	105 (44.7%)	232 (59%)
DMFT/dmft[b,c]		
0-7	33 (14%)	13 (19.4%)
8-10	64 (27.2%)	21 (31.3%)
11-13	62 (26.4%)	21 (31.3%)
≥14	76 (32.3%)	12 (17.9%)
Urgent Care History		
Yes	67 (28.5%)	67 (17%)
Total Wait Time until GA (mean)[d]		
Days	358 (SD ±149)	344 (SD ±166)
Days Until Urgent Care[e,f]		
	201 (SD±156)	177 (SD ±161)

[a] Mean Age; [SDF: 3.6 years, SD ± 2.0], [Non-SDF: 5.8 years, SD± 3.3]
[b] Average dmft/DMFT;[SDF: 2.48 (8-10 dmft/DMFT score), SD ± 1.1]
[Non-SDF: 2.44, (8-10 dmft/DMFT, SD ±1.1]
[c] DMFT/dmft and SDF correlation; [rho-.143, p=.000]
[d] Mean GA Wait Time; [SDF: 358 days, SD ± 149], [Non-SDF: 344 days, SD ± 166]
[e] Days to UC: [SDF: 201 days, SD ± 156], [Non-SDF: 177 days, SD ± 161], Significance (p=.380)
[f] SDF application is positively associated with having an UC encounter
((X2 (1, N = 628) =11.5 , p = 0.001)

Sixty-seven (28.5%) of the 235 who received SDF presented to UC at least once during the waiting period (Table III). The most common chief complaint for both groups was pain, with the most common treatment rendered being extraction (Figure 6). Treatment rendered for both groups at UC is depicted in Figure 7. The overall average time between placement on the waitlist and UC encounter was 189 days, (177 days for non-SDF group [SD+/- 161 days] and 201 days for SDF group [SD+/- 156 days]). The average time between placement on the waitlist and UC encounter was not statistically different between the SDF and non-SDF group (p=.380). There is a weak, but significant correlation between dmft/DMFT and receiving SDF (rho-.143, p=.000), where patients with higher dmft/DMFT scores tended to receive SDF application.

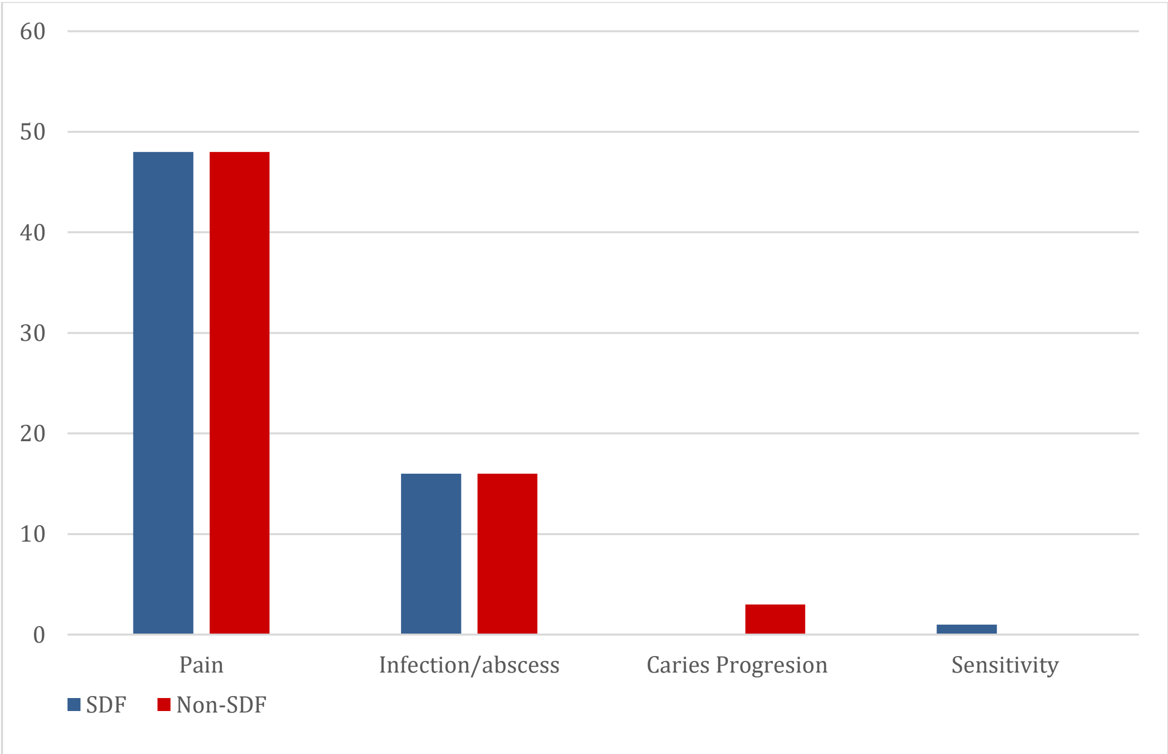

Figure 6: Chief Complaint at Urgent Care Visit One, SDF vs Non-SDF

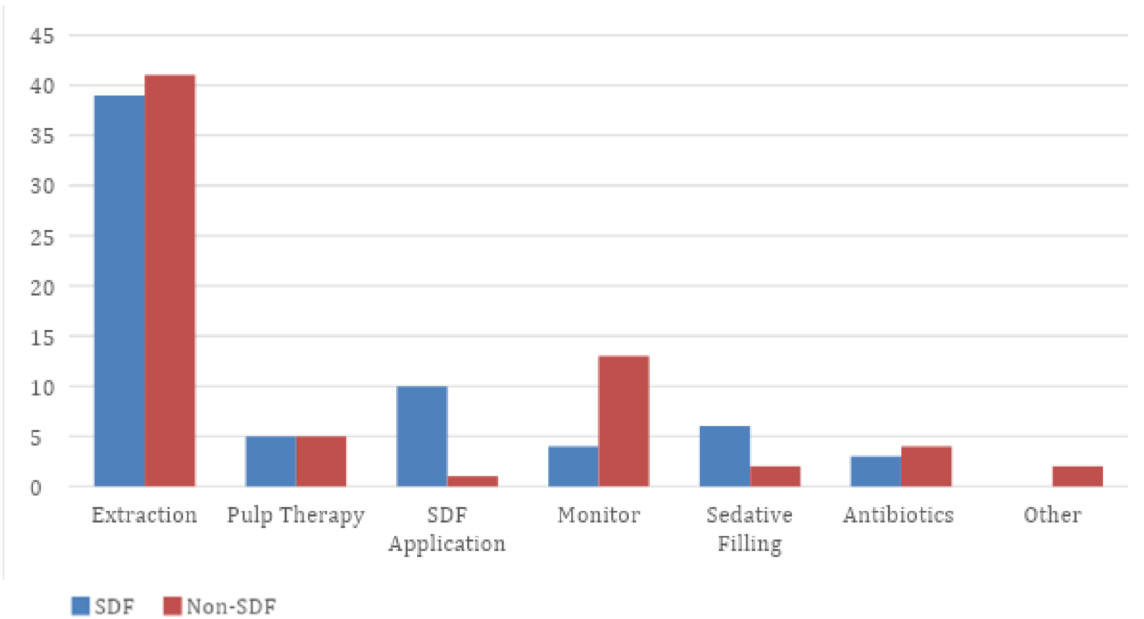

Figure 7: Treatment Rendered at Urgent Care Visit One, SDF vs Non-SDF

To develop a more comprehensive understanding of the relationship between key variables identified in bivariate analyses as contributing to urgent care visits, we estimated a logistic regression model. The initial model included the following predictors: whether the child received SDF, dmft/DMFT category, child age, time on the GA waitlist, child ethnicity, and whether the child had special healthcare needs. All predictors were entered as a block. DMFT/dmft, child ethnicity, and SHCN status were not significant predictors in the initial model and were dropped from the equation. The revised model is depicted in Table IV. The strongest predictor in the model appears to be SDF application which increases the odds of a UC visit by 60 percent (p=.025). Increased child age appears to be associated with a modest but significant decrease in the odds of a UC visit (p=.000). Although statistically significant (p=.000), wait time appears to have a negligible effect when the other variables are controlled. SDF application is positively associated with having an UC encounter ((X^2 (1, N = 628) =11.5 , p = 0.*001)*.

Table IV
FINAL LOGISTIC REGRESSION MODEL PREDICTING URGENT CARE VISITS

Step 1[a]	B	S.E	Wald	df	Sig.	Exp(B)[b]	Lower	Upper
SDF	.478	.213	5.013	1	.025	1.612	1.061	2.45
Age	-.095	.042	5.027	1	.025	.909	.837	.988
GA wait time	.003	.001	15.254	1	.000	1.003	1.001	1.004
Constant	-2.019	.382	27.904	1	.000	.133		

[a] Variables entered on Step 1: SDF, Age, GA wait time
[b] 95% confidence interval

5. DISCUSSION

5.1 General Anesthesia Wait Time and the Impact on the Frequency of Adverse Events and Subsequent Urgent Care Visits

Complete oral rehabilitation under GA is often indicated and recommended for children who have extensive oral healthcare needs, acute situational anxiety, and the inability to cooperate. While GA has been viewed as a good treatment option for many children, including those with special health care needs, one of the main challenges is providing complete oral rehabilitation in a timely manner. Children who receive dental treatment under GA may have to wait for months to years before dental treatment can be performed, as seen in this study.

Factors that influence wait times for GA include provider availability, hospital or outpatient surgery center availability, and degree of disease burden and need. In areas with limited provider availability, heavy disease burden and need for GA, and/or limited access to hospital/outpatient surgical center access, wait times increase. Poor Medicaid reimbursement for dental care under GA and associated facility fees may negatively impact GA wait times (54). Many hospitals may limit operating room time for complete oral rehabilitation under GA because of low reimbursement rates (54), providers may limit the number of days they offer GA as well. Consequently, providers are only able to see a limited number of patients, extending wait times for GA (25). White et al.(55) found that increasing Medicaid coverage for GA and medical charges associated with dental treatment as well as passing legislation requiring health insurance plans to cover dental insurance plans ultimately improved access to care. Beazoglou et al. (56) found that the increase in children's Medicaid dental fees to match approximately the 70th percentile of what the market fees were for dental care had a significant impact on reducing disparities in children's access to dental care in Connecticut.

Many of the pediatric patients seen at UIC COD are preschool to school-aged, have a high disease burden, and are Medicaid beneficiaries. During the time period studied (2017-2020) pediatric dental residents and faculty were able to provide complete oral rehabilitation in a hospital setting once a week treating 4-6 patients. At UIC COD, patients had to wait on average one year for dental treatment under GA. The long wait time increased the risk of returning for emergency treatment prior to the surgery date. In an effort to reduce GA wait time, an increase in provider availability, facility availability, and Medicaid reimbursement fees should be considered.

Patients waiting for definitive treatment under GA for long periods of time are impacted negatively. These impacts include need for analgesics and antibiotics because of pain and infection prior to GA date, sleep disturbances, and problems with eating (31). In a study by North et al. (33) half of a cohort of children who had their dental treatment under general anesthesia postponed by six months, who returned for reassessment, sought dental advice during their wait. Of the aforementioned cohort, more than one-third of patients required analgesics for pain management during the wait and almost half were prescribed antibiotics on at least one occasion. Parents also reported patients had problems with sleeping, eating, and had missed school days because of the consequences of untreated caries. Similar to the aforementioned study, many of the patients in our study were negatively impacted (experienced pain, infection, sensitivity, disturbances of sleep, and problems eating) during the wait for GA.

In a study by Shqair et al. (36), eighty percent of patients who presented to a university pediatric dental clinic for dental emergencies had a chief complaint of pain caused by dental decay. Our study produced similar findings as the most common chief complaint at UC presentation in this study was pain related to caries. This means that roughly 15% of all patients on the UIC COD GA waitlist presented to UC with a chief complaint of dental pain. For 96 patients caries progression led to pain, negatively impacting their overall quality of life as well as their oral health related quality of life. This number may not represent the total population, as patients who experience dental emergencies after hours may present to an emergency department for care, seek treatment at outside clinics/clinics closer to home, or go without seeking dental treatment altogether. This is an alarming number of patients who are impacted negatively by increased wait times for comprehensive dental treatment, which suggests that a one-year waiting period is simply too long for children needing complete oral rehabilitation under GA.

The most common procedure completed at UC was extraction as over half of the total UC population received this treatment. This is true for the total population at both UC visit one and two, SDF group who presented to UC, as well as for children with SHCN who presented to UC. Approximately 14% of the total study population received at least one extraction during their wait for GA. While the caries extent was not documented at the time of waitlist placement, it is likely that the teeth extracted could have already been considered hopeless. Since many patients were placed on the waitlist because of uncooperativeness, oftentimes radiographs were not taken. Without radiographic information, there was no way to determine accurate depth of caries at presentation. Because of this, there is no way to determine if some of the carious lesions were affecting the pulp at the time of placement on the waitlist. It is also possible that some of the teeth extracted may have had the potential to be restored and remain functional if definitive treatment was completed earlier. Lastly, given that the average age of patients who presented to UC was 4 years old, they should ideally receive space maintainers due to the premature loss of their primary teeth.

Two-thirds of the total UC population required the use of protective immobilization. This sheds light on the behavior and cooperability of patients on the waitlist who present to UC, as well as the experience of these patients presenting to UC. Use of protective immobilization may be traumatic for the patient, the parent, and the provider especially when the patient is young and/or with special health care needs that preempt them from comprehending what is happening. In an effort to prevent patients from experiencing pain and having a possibly traumatic experience at UC, it should be a goal to reduce wait time for patients on the waitlist to 6 months or less, regardless of SDF placement or not.

5.2 Comparison of SHCN and Healthy Population at UC

Patients with SCHN who are unable to cooperate or tolerate dental treatment are often indicated for complete oral rehabilitation. In this study, when compared to the healthy population, patients with SHCN presented with lower dmft/DMFT and received SDF less frequently than the healthy population. Healthy patients who presented to UC tended to be younger and have higher dmft/DMFT. Patients with SHCN at UC presentation tended to be older, seemingly presented with less caries (possible examination was more difficult than the healthy population), and consequently received SDF less commonly than the healthy children. This trend may be explained by behavior and cooperativeness, the extent of the carious lesions would withstand the waiting period, or inability to tolerate treatment in the dental setting. Patients with SHCN may be less likely to be able to tolerate treatment in a dental setting (due to cooperability or medical condition) than the healthy population, necessitating GA for complete oral rehabilitation.

5.3 Association between SDF application and Prevention of Urgent Care Visits

SDF has been accepted as efficient and effective in arresting caries and decreasing dentinal sensitivity. In a study by Thomas et.al (38), it was found that applying SDF to the carious lesions of patients awaiting GA is a safe and simple way to provide temporary treatment while they wait for definitive treatment. SDF, in our study, was found to be used most frequently for children under age five and placement occurred at least once. This is consistent with the findings of Scully et al (57); in the US, patients under nine years old are more likely to receive SDF. Possible reasons for the average age of the SDF group observed at UIC COD may include ease of application in this population compared to other dental treatment, as well as increased parental acceptance in this age group. Parental acceptance of SDF increases when the patient's behavior presents as a barrier to receiving definitive treatment (58). Parental acceptance of SDF staining is higher in primary dentition compared to the permanent dentition and in posterior teeth compared to anterior teeth in either dentition (59). These findings suggest that parents are more likely to accept SDF placement when the child is younger (less cooperative), in primary dentition, and when SDF staining is limited to posterior teeth. In our current study, more patients received SDF at the initial exam which is also when more patients were placed on the GA waitlist. This may be related to dmft/DMFT score at the initial exam, as well as behavior and cooperability. Patients with higher dmft, extensive oral healthcare needs, acute situational anxiety, and the inability to cooperate are indicated for complete oral rehabilitation under GA. Often this can be evaluated at the initial exam.

Approximately one third of our sample received SDF and of those patients one third presented for UC prior to dental treatment under GA. Based on these findings, patients with higher dmft/DMFT score were more likely to receive SDF, and those patients were more likely to have an urgent care encounter. However, our study showed that SDF application delayed presentation to UC although it was not statistically significant. This is similar to the findings of Thomas et al. (38), in which the application of SDF was found to help prevent emergency visits among pediatric dental patients while they await GA or oral sedation. Placement of SDF during GA wait periods can be considered a treatment option to reduce risk of presentation to UC due to negative sequelae of dental caries progression. Seventy percent of children who received SDF typically had only one application within the wait period, whereas the remaining patients received two or more applications at their 6-month recall visits that they presented to. Based on our analysis, multiple SDF applications did not reduce the likelihood of an UC encounter.

For patients who received SDF and had a UC encounter, it is important to note that SDF has limitations in arresting caries when lesions are large/encroaching on the pulp and application conditions are not ideal. Many patients are placed on the waitlist because of their inability to cooperate for dental treatment, which may make application of SDF difficult. If SDF is placed under less than ideal conditions, it is reasonable to assume effectiveness of caries arrest may be affected as well. When carious lesions are large and approaching the pulp, SDF does not induce pulpal inflammation or necrosis, but larger lesions may require more applications of SDF to have effectiveness in arresting caries and desensitization (60,61). In young and/or uncooperative patients and patients with large carious lesions more frequent SDF application recalls may increase the efficacy of the SDF to completely arrest caries. With less cooperation, more frequent applications may provide more opportunity to adequately apply and arrest dental caries.

This retrospective study analyzed patients on the waitlist at UIC COD from 2017-2020. This was prior to the opening of the outpatient surgicenter within the COD in which healthy, non-medically compromised patients receive complete oral rehabilitation under GA. Separating

GA location for healthy, non-medically compromised patients from patients with SHCN and/or medically compromised patients has helped reduce wait times for complete oral rehabilitation under GA for both groups. Prior to the opening of the Outpatient Care Center (OCC), patients placed on the waitlist experienced average wait times of 359 days for GA, approximately one year, in a hospital setting. With the opening of the OCC, many patients are able to be seen in a more timely manner. This reduction in wait time has the potential to reduce patients' negative dental experience (pain, infection, need for UC, etc.) while waiting for complete oral rehabilitation under GA.

6. CONCLUSION

At UIC COD, during the period our study was conducted, the average wait time for GA was about one year, with a UC presentation occurring around 6 months after GA waitlist placement. In this sample, there was a positive correlation between patients' GA wait time and UC presentation. Those who received SDF and presented to UC presented after longer periods of time than those who presented to UC but had not received SDF. While the application of SDF in the present study delayed the time until presentation of UC, it was not found to be statistically significant.

Most commonly, patients who presented to UC were under five years. Pain, followed by infection was the most common reason for presentation to UC. This suggests that younger patients, with and without SHCN, are most commonly affected by adverse events like dental pain related to untreated caries/caries progression. To reduce risk of an adverse event in patients waiting for complete oral rehabilitation under GA, wait time should be less than 6 months. The use of SDF shows potential in reducing risk of an adverse event while waiting for GA however more studies are needed to determine the appropriate frequency of application to significantly reduce risk of adverse event and UC presentation.

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7. APPENDICES

APPENDIX A: Data Collection Table

	Patient 1	Patient 2	Patient 3
Age			
Sex			
Race[1]			
Ethnicity[1]			
SHCN[2]			
DMFT			
SDF Y/N			
Appt @ SDF applied			
# SDF app			
GA waitlist visit type			
Date GA waitlist[3]			
Date GA completed[3]			
UC (Y/N)			
#UC			
Date of UC 1[4]			
CC @ UC 1			
Procedure compl. UC 1			
Date UC 2[3]			
CC @ UC 2			
Procedure compl UC 2			
Date 3rd UC[3]			
CC @ #3 UC			
Procedure compl UC 3			
Papoose (Y/N)			
additional notes			

[1] Race and Ethnicity as defined by the U.S. Census Classification System. Race indicating if White, Black or African American, Asian, American Indian and Alaska Native, Native Hawaiian, Pacific Islander, or Other. Ethnicity indicating if Hispanic or Non-Hispanic.

[2] Special Needs as defined by a diagnosed development, psychiatric, physical, or medical disability.

[3] Dates were removed following calculation of Days (Day of GA completion – GA waitlist placement = Total days on Waitlist; Day of 1st UC visit – GA waitlist placement date = Total days until first adverse event

VITA

NAME	Briana S. Moody
EDUCATION	B.A., African American Studies, Saint Louis University, Saint Louis, Missouri, 2015
	D.D.S., Marquette University School of Dentistry, Milwaukee, Wisconsin, 2019
	M.S., Master of Oral Science, University of Illinois Chicago, Chicago, Illinois, 2021
TEACHING EXPERIENCE	Department of Pediatric Dentistry, University of Illinois Chicago College of Dentistry Undergraduate Pediatric Clinic, Chicago, Illinois, 2020-2021
RESEARCH EXPERIENCE	Principal Investigator, University of Illinois Chicago College of Dentistry, Chicago, Illinois, 2019-2021
PROFESSIONAL MEMBERSHIPS	American Academy of Pediatric Dentists (AAPD) American Dental Association (ADA) National Dental Association (NDA)